Misuse of Antibiotics in China's Animal Husbandry Industry: Causes and Economics Implications

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Abstract

The quick emergence of China's antibiotics industry as the world leading producer had benefited from the large and rapidly growing domestic market and the economies of scale in production. However, China's antibiotics industry is still in the development stage. Relative to the industries in the developed countries such as the US, Europe and Japan, China still lags behind in terms of R&D capacity and manufacturing skills because about 70 percent of the output are generic drugs and the industry concentrates mostly in the production of low-end crude materials. The "xiankangling" (order to restrict antibiotics use) adopted by the Chinese government in 2012 dealt a fatal blow China's antibiotics manufacturers. Since then, the growth of the industry turned into prolonged sluggishness. In 2013, China accounted for more than half of the global total consumption of antibiotics, of which over 50 percent was used on livestock. However, the rate of inappropriate use of antibiotics in animal farming could reach as high as 60 percent to 90 percent in China. The distorted market incentive structures and the weakness in the administrative capacity building were mainly responsible for the widespread antibiotics misuse in China's foods producing animal industry. It is proposed in this study to adopt a marginal damage tax to correct the distorted market incentives and allow third party instituions to help monitor use of antibiotics in animals and assess the potential risks. At present, the Chinese government is still trying to seek a compromise over the use and non-use of antibiotics in food producing animals for non-therapeutic purpose. This policy involves high risks. By using SARS that broke out in China in 2003 as the reference, it is estimated that the direct output loss in China's animal husbandry industry would be over 467 billion *Yuan* at minimum if there was a full-blown AMR crisis in the near future. It is a conservative estimate as it is generally believed that a full-blown AMR crisis would be much more serious (O'Neil et al 2014). However, the results are sufficient to warn the policymakers that the actual damage to China's animal husbandry industry as well as the whole society could be much worse if there was a major AMR crisis.

Introduction

China is the world's largest producer and consumer of antibiotics products. The country produced 90 percent of the world's antibiotic crude materials and exported 70 percent of the world's total. Each year, China consumed around 160,000 tons of antibiotics, accounting for 50 percent of the global total consumption and each individual Chinese consumed, on average, 5 times that of the west. Of China's huge consumption of antibiotics, around 50 percent were used on livestock.

China is on the list of most vulneruble countries to a possible full-blown antibiotics crisis in the world. However, despite the widespread use of antibiotics, very little percentage of the vast Chinese population have ever heard of the term AMR (Antimicrobial resistance) or *"kangshengsu naiyaoxing"*, neither are fully aware of the seriousness of the situation. In recent years, some research studies and media began to disclose stories about the antibiotics abuse in humans and in food producing animals in China (see Appendix 4). These efforts have helped prompt quicker actions by the government. In recent years, the Chinese government has launched two major campaigns, first to combat misuse of antibiotics on humans in August 2012 by the China Ministry of Health (CMH) and second to adopt a five-year action plan in July 2015 by the China Ministry of Agriculture (CMA) to combat misuse in food-producing animals. However, the future direction of the antibiotics use is still in the middle of heated debates, particularly for the country's giant animal husbandry industry.

At present, the Chinese government is trying to seek a balance between use and non-use of antibiotics in food producing animals for non-therapeutic. The proponents for continued use of antibiotics in food producing animals mainly based their argument on the importance of food supply for national security, misuse by decentralized farmers being the nature of the problem, inadequate enforcement and overstated effects of antibiotics use. On the other hand, the opponents emphasized the impending crisis for the humans, availability of alternatives and negative impact of discriminatory nature of higher-foreign standards on domestic production and international trade. In practice, the Chinese government seems to have adopted a multifaceted approach including setting up standards, educating on prudent use, strengthening monitoring and cracking down on misconducts.

Antibiotics misuse has important welfare implications. The current incentive structures encourage the widespread use of antibiotics. As the market price is set below socially optimal level and information about the products is asymmetric in favor of antibiotics suppliers, consumers or users of antibiotics tend to over-consume, ending up as the victims or net losers of antibiotics misuse. On the other hand, the profit-driven suppliers including both antibiotics manufacturers and final goods (and/or services) that contain antibiotics, have the incentive to over-supply antibiotics to the market because they are not required to pay compensation for the social damage caused by their behavior.

The Chinese government plays a key role in controlling the spread of resistant bacteria in this largest market of the world that is characterized by a highly decentralized model of animal farming. In addition to the distorted incentive structures, under-supply of public services such as monitoring, legal enforcement and identification of potential risks by the highly centralized governance structure seems to be mainly responsible for the worsening of the problem at least in the short term. With inadequate staff, conflict of goals within one government agency and under-supply technologies, the government had to rely heavily on high-cost periodic campaigns to control the spread of abuse while other social institutions played only limited role in the battle against the spread of AMR. There is already evidence that some well-to-do families who have refused to consume the monitoring services supplied by the government agencies to contract directly with farmers for antibiotic-free food, or purchase them from high-standard foreign countries.

Three aspects are essential in winning the battle against the spread of resistant bacteria-very prudent use of antibiotics to slow down the evolution of drug-resistant strains of infectious bacteria, accelerating the development of new drugs and testing for new alternatives to antibiotics especially in food producing animal industry. In practice, there seem to be an imbalance in the allocation of resources in the three arsenals to combat AMR as substantial efforts have focused on disciplining the current use of antibiotics, not the medium and long-term solution to the problem.

This study exclusively focuses on the antibiotics use in China's animal husbandry industry. To help understand the problem, we first attempt to review the development of China's antibiotics industry to show how it had developed into a leading producer of crude drugs in the world (Section II). Then we analyze the motivations of inappropriate use of antibiotics in China's animal farming industry (Section III) and how the Chinese government had tried to deal with the problem of antibiotics misuse in practice (Section IV). Finally, we examine the economic implications of inappropriate use of antibiotics for China's animal husbandry industry (Section V).

Ⅱ. Development of China's Antibiotics Production and Challenges

China is the largest producer of antibiotics in the world. In 2013, China's total antibiotics production reached 197,000 tons (see Table 2.1).[1] 34,300 tons or 28.3 percent of the total output were exported to the global markets in 2013, with China accounting for 70 percent of the world's total antibiotics exports (Table 2.2). While antibiotics is the leader in China's total crude or raw-material drugs exports with an amount of USD2.2 billion and 9.53 percent of the share in 2013, its importance in the country's total export activities was insignificant, with a share of only 0.1 percent.

China's competitive advantage in antibiotics production is mainly in crude materials. In 2013, It accounted for 90 percent of the world's total antibiotic crude materials production. India is China's main competitor in the global antibiotics market. However, India's competitive advantage is mainly in the production and export of 7-ACA[2] whereas that of China mainly in such antibiotic fermentation products as penicillin, tetracycline, oxytetracycline, gentamycin, lincomycin, streptomycin and spiramycin.

In 2013, China accounted for 90 percent of the world's antibiotic crude drug production and 70 percent of the world's total antibiotics exports

Table 2.1 China's antibiotics production（10,000 tons）

Year	Antibiotics output, total	veterinary (crude)
2007	13.4	—
2008	15.4	—
2009	18.2	—
2010	21.8	3.18
2011	22.3	4.70
2012	21.2	5.25
2013	19.7	5.95
2014	—	5.30

Source: *China's Antibiotics Markets: An In-depth Analysis and Prospect* 2015–2020 <http://www.chyxx.com/research/201502/306230.html>. Data for veterinary drugs were obtained from China Ministry of Agriculture.

1 There were different estimates about China's antibiotics production and trade. According to Zhang, Yin et al (2015), China's antibiotics production was 162,000 tons and export value was USD2.191 billion as cited in the text in 2013.

2 7–ACA are generally used as the basic materials for producing semi-cephalosporins.

Table 2.2 China's antibiotics exports (10,000 tons)

Year	Exports, total	veterinary (crude)
2008	8.0	—
2009	9.0	—
2010	10.0	0.65
2011	11.9	0.60
2012		0.73
2013	3.43	0.97
2014	—	0.99

Source: *China's Antibiotics Markets: An In-depth Analysis and Prospect* 2015–2020. Data for veterinary drugs were obtained from China Ministry of Agriculture.

Note: 2013 total export data is only for reference. Due to unknown reason, the data seemed inconsistent even from the same source.

To have some insights about the structure of Chinese antibiotics trade, Table 2.3 shows the export and import of different categories of antibiotics. In 2015, China's total trade in crude drugs was about USD4.2 billion with a surplus of over USD3.2 billion in China's favor. Veterinary drugs accounted for about 19 percent of China's total crude antibiotics exports. Penicillin is the leading exporter of all the product categories. In 2015, China's total penicillin export was USD892.2 million, accounting for about a quarter of China's crude antibiotics drug exports. China mainly imported preparations in antibiotics trade. It imported USD 13.33 billion of preparations as compared USD471.56 billion of imports for crude drugs in 2015. Tetracyclines is the leading exporter of veterinary drugs for China. It exported USD280 million of Tetracyclines in the year 2015.

Table 2.3 Antibiotics export and import of China, 2015 (USD10,000)

Products	Export	Import	Export and import	Export, veterinary drugs
Crude drugs	370734.00	47156.00	417890.00	69500.00
Aminoglycosides	10265.86	3.07	10268.93	—
Macrolides	20683.2	198.06	20881.26	14500.00
Sulfonamides	3794.47	689.9	4484.37	3000.00
Lincomycin	18291.93	2.08	18294.01	14500.00
chloramphenicols	18659.21	4.36	18663.56	9500.00
Other anti-infection antibiotics	130795.8	29102.12	159897.9	—
Penicillins	89218.13	41.82	89259.95	—
Tetracyclines	35395.3	947.31	36342.61	28000.00
Cephalosporins	43630.69	16167.59	59798.28	—
Praparations	319796.6	1321652.00	1641449	
Other anti-infection antibiotics	49364.08	88691.21	138055.3	
Penicillins	12620.45	6934.9	19555.35	
Cephalosporins	12472.29	6934.9	32874.14	

Source: China Medical and Health Import and Export Association.

China was among the 7 pioneer countries (including UK, the US, France, the Netherlands, Demark and Sweden) to have developed the penicillin product in 1944. One year after the founding of the People's Republic in 1949, China succeeded in developing the penicillin potassium salt and put it into production in Shanghai No.3 Pharmaceutical Factory.[3] At that time, the country's total output of antibiotics was only several dozens of tons. Over the last 60 years, China was able to make tremendous progress in its productive capacity, especially since the inception of the policy of reform and opening up to the outside world. By the year 1999, China had established approximately 200 antibiotics producing enterprises, capable of producing about 100 varieties of antibiotic crude drug materials.

China's accession to WTO in 2001 provided new opportunities for the industry to engage with international counterparts. The antibiotics products started to penetrate into the international markets at an accelerated pace. Before the end of 2009, China emerged as the world's largest producer and exporter of antibiotics and the size of domestic market grew to 60 billion *Yuan* with over 180 antibiotics varieties being produced.

China was among the 7 pioneer countries (including UK, the US, France, the Netherlands, Demark and Sweden) to have developed the penicillin product in 1944.

China's quick rise as the world's leading producer of antibiotics had exhibited three prominent features. First, the industry was characterized by the rapid expansion in the scale of the production. Relative to the producers in other countries, the Chinese antibiotics producers had two major advantages, namely, the enormous and rapidly growing domestic market and, the economies of scale in production. These two advantages gave the Chinese antibiotics producers the privilege of a large domestic market and low production costs. By the year 2009, China had set up about 120 antibiotics producing enterprises with an output of 180,000 tons. In particular, the output of major categories of crude drugs including penicillin, cephalosporins, beta-lectams, Aminoglycosides, teracylines, macrolides, quinolones and anti tuberculosis reached 147,000 tons.

To further demonstrate the rapid expansion of China's production in antibiotics, we may look at some of the products included in *The National Catalogue of Basic Drugs* published by the China Ministry of Commerce in 2009.[4] From 2000 to 2009, the output of Penicillin potassium salt increased from 10,000 tons to 56,000 tons, up by 475 percent. The output of amoxicillin increased by 614 percent during the 10-year period to 14,000 tons while that of cafalexin and ceftriaxone increased by 762 percent and 3584 percent, respectively. By 2009, China could export 3,500 tons of amoxicillin and 400 tons of ceftriaxone.[5] China had become self-sufficient in most of the antibiotics products. Table 2.4 shows the output of some of China's antibiotic preparations from 2002 to 2009.

Relative to the producers in other countries, the Chinese antibiotics producers had two major advantages, namely, the enormous and rapidly growing domestic market and, the economies of scale in production.

3 The penicillin was first developed in Kunming, China by a team led by Professor Fan Qingsheng in 1944 with the assistance from American Bureau of Medical Aid to China. Professor Fan received his PhD from Cornell University and returned to China to get involved in the war against Japan's invasion.

4 China Ministry of Health started to publish The National Catalogue of Basic Drugs in August 2009 and the Catalogue is updated every three years. 2015 is the latest version of this Catalogue.

5 The data is based statistics published the China Pharmaceutical Industry Association.

Table 2.4 Development of major antibiotic preparations, 2002–2009 (10,000 units)

	800,000u	0.5g	0.25g	0.25g	1g
year	Penicillin	Ampicillin Sodium	Amoxicillin Capsules	cefazolin sodium	Ceftriaxone
2002	689376	208835	930724	114657	27727
2003	620358	188960	1359008	122893	48594
2004	618597	177283	1374409	108559	83485
2005	568083	170782	1832843	113205	109876
2006	404533	131261	1953261	116261	118710
2007	442295	135658	1902042	95283	112041
2008	443092	114176	2146502	82695	124674
2009	410000	110000	220000	83000	160000
change（%）	–40	–47	136	–28	477

Source: China Pharmaceutical Industry Association, www.askci.com

The second feature of the development of China's antibiotic industry is the fast pace of modernization. Now China is among the world leaders in the technologies of antibiotics production. Antibiotics fermentation and purification process were fully automated. More productive bacterial strains were selected through genetic engineering process and intermediates were synthesized with latest enzymatic Technologies. Tests of new microbial strains were carried out through China's "Shenzhou" spaceship to develop new drugs for animals. China also became capable of developing a good number of its own products. Table 2.5 shows the antibiotic products produced by the Chinese firms in the domestic markets by the year 2011.

Table 2.5 Cephalosporins drugs sold in the domestic market by 2011(1st–4th generations)

No.	Product	Gen.	Product	Gen	No.	Product	Gen.
1	Cephalothin	I	Cefotiam	II	23	Cefmenoxime	III
2	Cephradine	I	Cefmetazole	II	24	Cefodizime	III
3	Cephlexin	I	Cefaclo	II	25	Cefdinir	III
4	Cefadroxil	I	Cefprozil	II	26	Ceftazidime	III
5	Cefazolin	I	Cefpodoxime	III	27	Cefoperazone	III
6	Ceftezole	I	Cefteram	III	28	Cefminox	III
7	Cephathiamidine	I	Cefetamet	III	29	Latamoxef	III
8	Cefuroxime	II	Ceftriaxone	III	30	Cefpiramide	III
9	Cefoxitin	II	Cefotaxime	III	31	Cefepime	IV
10	Cefamandole	II	Ceftizoxime	III	32	Cefoselis	IV
11	Cefonicid	II	Cefixime	III	33	Cefpirome	IV

Source: China Pharmaceutical Industry Association, www.askci.com

The third feature of the rapid expansion of China's antibiotic industry is internationalization. After China's accession to WTO in 2001, its antibiotics market became more open. Domestic firms actively participated in international accreditations such as the US Food and Drug Administration (FDA),the European Certificate of Suitability (COS), Japan's PMDA, Australia's Therapeutic Goods

Administration （TGA）and Canada's Therapeutic Products Directorate (,TPD), leading to closer alignment with the international standards for China's antibiotics production. Table 2.6 shows some representative Chinese pharmaceutical firms that had passed the FDA accreditation procedures by 2011.

Table 2.6 Representative Chinese producers of crude drugs with FDA accreditations by 2011

firm	accreditated products
Jiangxi Dongfeng Pharm.	penicillin
Huabei Pharm.	Amhotericin B
Zhejiang Hisun Pharm.	Adracin Hygrocloride, Daunnomycin Hygrocloride, Mitomycin, Tobramycin Base and Bleomycin sulphate
Zhaoqing Xinghu Pharm.	Ribavirin

Source: China Pharmaceutical Industry Association, www.askci.com

Entry by the foreign pharmaceutical companies via joint ventures and outsourcing was another driving force for the rapid expansion of China's antibiotics industry. For example, Zhejiang Hisun set up a joint venture with Eli Lilly to produce Capreomycin. Lukang Pharmaceutical Company entered into a joint-venture arrangement with Japan's Meiji to produce medemycin and Colistin Sulphate. Gunagdong Baiyun established partnership agreement with DSM in 2011 to take advantage of DSM's high-quality raw materials to upgrade successfully its production of Amoxicillin, Cephradine, and Cefalexin and Huabei Pharmaceutical Company set up a joint venture with Indian Orchid Pharm. to develop 7–ACA varieties.

However, China's progress in the antibiotics production is mainly reflected by the rapid expansion in quantity, not quality. Compared with the developed countries such as the US, Europe and Japan, China's antibiotics industry still lags behind in terms of R&D capacity, manufacturing skills as about 70 percent of the output are generic drugs and the industry concentrates mostly in the production of low-end crude drugs. For example, in contrast to penicillin and 7–ACA, China's exports of the downstream products such as semi-synthetic penicillin, cephalosporins and preparations accounted for less than 5 percent of the global market.

At the present stage, the industry is faced with three major challenges, overcapacity, shrinking export markets and regulatory restrictions imposed by the government to protect the health of humans and food-producing animals. The issue of regulatory changes will be discussed in detail in Section IV of the article. In the following, the problems of overcapacity and shrinking export market are discussed briefly.

Overall, China's pharmaceutical industry is in a state of overproduction, with only 55 percent of the capacity in operation in 2012.[6] In 2011, the size of China's antibiotics market expanded to over 100 billion *Yuan*.[7] Antibiotics used to have the largest share of clinical use of drugs, accounting for 24 percent in 2010. The Cephalosporins were the leading products in the market. In 2010, the size of cephalosporins' end-user market reached 43 billion *Yuan*, up by 20 percent over the previous year and accounted for 50 percent of the total domestic antibiotics market. However, the growth of penicillin and macrolide antibiotics saw a trend to decline in recent years. Due to AMR and

6 Author's own calculation.

7 ASKCI Consulting, *China's Antibiotics Markets: An In-depth Analysis and Prospect* 2012–2016, 2012.

toxic effects, the market fortetracyclines and aminoglycosides shrank substantially.

Given that China's antibiotics overproduction was partly driven by the overuse of antibiotic drugs, the Chinese government started to curtail on the antibiotics production through cracking down on overuse and misuse of antibiotics in hospitals and animal farming in 2011. The campaign first targeted the use of antibiotics in the second-tier Chinese hospitals by outlawing the overpriced and ineffective drugs.[8] Gradually, the campaign extended to rural areas to control the combined overuse/misuse of antibiotics with hormone and vitamin on a non-discriminatory and regular basis by the hospitals.[9] Consequently, the market for low-quality penicillin, cephalosporins and macrolide for which skin test was not required dropped drastically. The market for the third and the fourth generation cephalosporins, counter-resistance preparations and 4-quinolone was most affected by the government crackdowns. On August 1, 2012, China Ministry of Health issued the most stringent restrictions on clinical use of antibiotics, generally called "xiankangling" (order to restrict antibiotics use) by the public.[10] The tightened rules dealt a fatal blow to China's antibiotics manufacturers. Since then, the growth of the industry has turned into prolonged sluggishness.

"xiankangling" adopted in 2012 dealt a fatal blow China's antibiotics manufacturers. Since then, the growth of the industry turned into prolonged sluggishness.

"Xiankangleng" had a major impact on the structural adjustment of China's antibiotics industry. The clinical demand for antibiotics dropped significantly. From 2010 to 2013, the share of antibiotics use for hospitalized patients in China's large and comprehensive hospitals fell from 68 percent to 53.5 percent and the intensity of the individual patient's use was cut by over 50 percent. The share of antibiotics prescriptions for outpatients dropped from 22 percent to 14.8 percent, while surgery applications of antibiotics as preventives reduced from 95 percent to 24 percent.[11] The productions of Cefepime cefpiramide and plicaclavulanate potassium for injection which were included in the government's list of restrictions fell 8.7 percent, 33.4 percent and 53.8 percent, respectively, in 2012. Furthermore, ampicillin sodium and Cefazolin Sodium for injection all fell by over 20 percent.[12] Today, the increased awareness of the general public about the negative impact of antibiotics use on human health and the tightened government regulations for human and animal use of antibiotics put strong pressure on the Chinese antibiotic firms.

In the international market, overproduction and rising concerns about the potential risks of antibiotics use by the public and the corresponding actions taken by the various governments to combat the inappropriate use also posed serious challenges to China's antibiotics industry. Under pressure, the number of anti-dumping cases against Chinese manufacturers' cephalosporins exports rose significantly as the Chinese exporters undercut each other to maintain the market share for the products. For instance, India successfully launched an anti-dumping investigation

8 It is believed that medical abuse of antibiotics is common in China. While the practice of large hospitals is well under control, medium-and small-sized hospitals and the food animal producer generally lack the discipline. Some doctors depend on antibiotics as an immediate remedy, and hospitals encourage doctors to use antibiotics for profit reasons.

9 The share of antibiotics use in the Chinese hospitals averaged about 30 percent. However, for smaller rural and township hospitals, the share was a lot higher and some could reach 50 percent. See ASKCI Consulting, China's Antibiotics Markets: An In-depth Analysis and Prospect 2012–2016, 2012.

10 The order issued by the Ministry of Health on August 1, 2012 was Administrations Rules for Clinical Use of Antibiotics (Order 84, Ministry of Health).

11 China Pharmaceutical Industry Association.

12 Same as above.

against ceftriaxone sodium exports from China. The consequent anti-dumping duties charged by the Indian government were about at the same level as the Chinese factory price. In another example of overproduction, the global demand for industrial penicillin salt was between 60,000 tons and 70,000 tons around 2013. But China's total capacity exceeded 100,000 tons. As a result, the price of industrial penicillin salt started to drop before the end of 2007. Beginning in 2008, the price dropped to 50 *Yuan*/BOU (about USD6/BOU) from the high of 150 *Yuan* (about USD25/BOU) registered in the third quarter of 2007.[13] In 2014, the price still remained at about 50 *Yuan*/BOU and export price quoted was around USD 8.[14] For 7–ACA, the world market demand was about 4000 tons, but China's capacity was close to 8000 tons.

With serious overproduction and global boycott against widespread use of antibiotics in humans and food producing animals, China's huge antibiotics industry could not continue in the way as before. It has already taken too much time for the industry to act. As AMR rates are worsening at home and globally and a major health crisis is becoming more imminent, China's giant antibiotics manufacturers must take a responsible role in developing new/alternative drugs to antibiotics both for humans and food producing animals, contributing to the establishment of a global multi-stakeholder steered fund to coordinate AMR research, promoting an effective ban on the non-therapeutic use of antibiotics and contributing to the creation of a global multi-stakeholder information program that ensures visibility of the AMR threat.[15]

13 <http://blog.sina.com.cn/s/blog_53e2230d01008sc4.html>

14 HealthNet, March 3, 2014.

15 Adiningrat (2015)

Ⅲ. Antibiotics Misuse in Food Producing Animals in China

China is both the largest producer and consumer of antibiotics in the world. In 2013, China's total consumption of antibiotics was 162,000 tons (with about 200 product varieties), 160 times that of UK and 50 percent of the world. In 2014, 53,000 tons of antibiotics were used in food producing animals, and roughly 10,000 tons of antibiotics for animal use were exported.[16] Table 3.1 shows the output and export quantities of China's antibiotics used by the food producing animals from 2010 to 2014. It indicates that both output and export are hovering at high levels.

Table 3.1 China's antibiotics output and exports for use in food producing animals (10,000 tons)

Year	Output	Export	Export (USD100 million)
2010	3.18	0.65	—
2011	4.70	0.60	—
2012	5.25	0.73	—
2013	5.95	0.97	6.56
2014	5.30	0.99	6.76
2015	—	—	6.95

Source: Ministry of Agriculture. Export value of antibiotics was obtained from China Medical and Health Import and Export Association.

While there was much concern about the negative impact on ecosystem and human health, lack of systematic information on the detailed use and the emission inventory of antibiotics in China are preventing full understanding of the issue. Various studies in recent years have shown that the overuse of antibiotics had caused serious consequences to the health of the population. A widely cited survey conducted by Qiang Qiang Zhang, Ying Guoguang, et al (2015) estimated that China consumed more than half of the global total antibiotics in 2013. About 52 percent was used on livestock and 48 percent by humans.[17] They showed that the developed provinces such as Guangdong, Jiangsu, Zhejiang and Hebei are seriously polluted. The antibiotics emissions concentration in the densely populated east China was six times that in west China. The average concentration of antibiotics in the Chinese rivers was about 303 nanograms per liter, compared with 9 nanograms

16 In another estimate made by Professor Xiao Yonghong in 2006, around 46 percent of antibiotic crude drugs were used for the food animals in China.

17 Note that different sources tend to give different estimates about China's production and use of antibiotics for animals and humans. Data in Table 2.1 were obtained from the Ministry of Agriculture.

per liter in Italy, 120 nanograms per liter in the United States, and 20 nanograms per liter in Germany. In particular, the situation of the Pearl River was worrying because fishing was very intensive along the River basin.[18] They also found that the bacterial resistance rates in the hospitals and aquatic environments were related closely to antibiotic use, especially those antibiotics used in the most recent period. The study concluded that an estimated 54000 tons of the antibiotics in the environment came from sewage, medical wastewater, food animal production and aquaculture wastewater.[19]

Pigs and chickens are believed to be the largest consumers of antibiotics while in comparison, use of antibiotics in sheep and beef cattle farming is relatively modest.

Among the food producing animals in China, pigs and chickens are believed to be the largest consumers of antibiotics while in comparison, the use of antibiotics in sheep and beef cattle farming is relatively modest.[20] Inappropriate use is a common problem.

Some estimated that therate of inappropriate use of antibiotics in animal farming could reach 60–90 percent.[21]

There are several explanations for the inappropriate or excessive use of antibiotics by the Chinese food animal producers.[22] First, many meat and poultry producers administer low doses of antibiotics to healthy food animals to promote faster growth and offset the effects of overcrowding and poor sanitation. According to an unofficial estimate, roughly over 60 percent of antibiotics used by food producing animals was directed to promoting faster growth of the animals in China.[23] As a precautionary measure guided by misconceptions, many farmers tended to overuse antibiotics as disease preventives and even used banned drugs as feed additives.[24]

18 So far, the Chinese government has not allowed use of antibiotics in fishing. Therefore, the finding of antibiotics residues in the rivers may be attributed to the waste dump from another source or illegal use in fishing.

19 The study found that some pig farms, especially large farms with over 10,000 pigs, added more than a dozen antibiotics in the folder and water.

20 Globally, pig farmers use four times as much antibiotics per kg of meat as cattle farmers (Adiningrat 2015). There is much concern about fishing in China. However, according to anonymous Chinese officials, the risk is not as high as generally believed because the chemicals mainly left by water purification process posed a bigger threat to human health. Some Chinese experts argued that chemicals were more harmful than antibiotics. See, for example, Lu et al (2003).

21 *ASKCI Consulting, China's Antibiotics Markets: An In–depth Analysis and Prospect* 2012–2016, 2012.

22 In a survey 0f 1528 people about the causes of inappropriate use of antibiotics in food producing animals conducted by China Youth Newspaper XXX in 2010, 87.09% of the respondents believed that it was mainly due inadequate monitoring and enforcement, 75.9% believed that it was due to motivations for profits by producers, 73.2 percent believed it was due to motivations for profits by antibiotics producers and only 67.4 percent believed it was due to poor standards.

23 This estimate is much lower than that of the global average. Based on the information given by ASKCI Consulting, over 90 percent of the antibiotics used by food producing animals was for the non–therapeutic use. See ASKCI Consulting, *China's Antibiotics Markets: An In-depth Analysis and Prospect* 2012–2016, 2012. According of some estimate, the effecfive rate of feed additives was 10 percent in China's food animal production.

24 According to various reports and study, misuse of antibiotics take different forms including growth promoting, disease prevention, preference for new and highly effective drugs, long-term and continuous use, absence of veterinarians' instructions, use of counterfeited and substandard products, repeated use of different brands but same substance, violating drug withdrawal time, etc. China has adopted several regulations to govern the practice of drug withdrawal on the use of veterinary medicines including antibiotics. These regulations include mainly, but not limited to *The Practice of Veterinary Medicine of the People's Republic of China* (1992), *Standards of Veterinary Drugs* (2003) *and Rules and Regulations on the Administration of Veterinary Medicine* (2004). But the enforcement has been limited to mainly the large-size animal farms. It turned to be extremely difficult to monitor the numerous decentralized small farms.

Small-scale farms such as pigs, dairy and beef cattle farms accounted for over 70 percent of China's total production.

Small-scale farms such as pigs, dairy and beef cattle farms accounted for over 70 percent of China's total production. On the one hand, these farms suffer from poor hygienic conditions and inadequate facilities to treat livestock excreta. On the other, these small-sized and decentralized models of animal farming has made government supervision extremely difficult.

Roughly over 60 percent of antibiotics used by food producing animals was directed to promoting faster growth of the animals in China.

A second explanation is lack of technical skills and consciousness of food safety. With the poor hygienic and overcrowding conditions, small-scale farmers placed high expectations on the power of drugs to secure animals' health. Many farmers continued to use the same drugs for a long time and when the effectiveness of the drugs declined they tried to use them more intensively or combine with other antimicrobials.[25] Absence of technical assistance is another problem. Many farmers relied on their past experience or commercial ads in their choice of veterinary medicine. More serious is the wide use of human medicine in food producing animals.[26]

Inadequate institutional support to monitor and control is the third major cause of the problems. In China, the administration of antibiotics is shared by two government agencies. Unlike other countries in the world, the antibiotics used in humans are administered by the China Food and Drug Administration (CFDA) whereas the antibiotics used in animals are administered by the China Ministry of Agriculture. Consequently, there is a high cost of coordination between the two government agencies and lack of accountability is inevitable.

Conflict of goals is the fourth problem. The Ministry of Agriculture is responsible for both the development of agriculture and administration of the country's antibiotics use in animals. If the goal is to maximize agricultural production, the other goal to secure food safety may often be sacrificed as antibiotics may be used as promoters for animals' growth. The third aspect of the problem is that the division of responsibilities among producers, local governments and the central government is not clearly defined along the value chain. The producers should take up the responsibility to monitor the use of antibiotics in the production stage. But very few producers are able or willing to fulfill this responsibility. At the same time, both the local and the central government all get involved in the monitoring and control in the marketplace while long-term risk assessment and identification of the sources of risks are simply ignored.

In China, the administration of antibiotics is shared by two government agencies. The antibiotics used in humans are administered by the China Food and Drug Administration whereas the antibiotics used in animals are administered by the China Ministry of Agriculture.

25 In the category of macrolides which mainly includes kitasamycin, Tylosin, Spiramycin, erythromycin and Oleandomycin, kitasamycin is the only antibiotics approved by the Chinese government to be used as feed additives. See Announcement (No. 168) regarding the Standard Practice for the Use of Feed Additives, Ministry of Agriculture, 2001.

26 There are two important reasons for the Chinese farmers to substitute human medicine for the veterinary medicine. The first is due to farmers' misperception that human medicine is of higher quality and more effective. The second is that domestic productive capacity can not meet the market demand. However, to protect the interests of domestic antibiotics producers, the government maintained high barriers to import. Consequently, there is a shortage of supply of veterinary medicine in the domestic market.

The fifth explanation is related to the absence of the role played by veterinarians. The size of rural veterinarian population has been shrinking rapidly in recent years as many vets chose to move into urban cities to meet the high demand by animal pets. The advisory role commonly played by the vets is increasingly taken over by the salespersons of antibiotics companies that try to sell their products to the farmers.

Table 3.2 is a brief summary of the major causes of antibiotics misuse in China.

Table 3.2 Causes of antibiotics misuse

	Causes	descriptions
1	Productivity driven	Producers administer low doses of antibiotics to healthy food animals to promote faster growth and offset the effects of overcrowding and poor sanitation. Roughly over 60 percent of antibiotics used by food producing animals was directed to promoting faster growth of the animals.
2	Lack of skills & food safety consciousness	Small-scale farmers placed high expectations on the power of drugs to secure animals' health. Many continued to use the same drugs for a long time and when the effectiveness of the drugs declined they tried to use them more intensively or combine with other antimicrobials. Also many farmers relied on their past experience or commercial ads in their choice of veterinary medicine. Human medicine is often used food animals.
3	Inadequate institutional support	Administration of antibiotics is shared by two government agencies. Lack of accountability is inevitable. Conflict of goals is another problem. The Ministry of Agriculture is responsible for both the development of agriculture and administration of the country's antibiotics use in animals. Confusion in responsibilities among producers, local and central governments also exists.
4	Absence of role by vets	High demand by animal pets induced vets into urban cities. The role of vets is often taken over sales people from antibiotics companies.

Source: *China's Antibiotics Markets: An In-depth Analysis and Prospect* 2015–2020 <http://www.chyxx.com/research/201502/306230.html>. Data for veterinary drugs were obtained from China Ministry of Agriculture.

Ⅳ. Regulatory Efforts to Combat Abuse: Tough Road to be a Global Leader

China has watched closely the changes in the antibiotics regulations in the developed countries and responded to the change by gradually establishing its own regulatory framework to deal with the misuse of antibiotics in food producing animals (Wang 2006). The major objective of China's official policies is to alleviate the negative impact of antibiotics residues, antimicrobial resistance (AMR) and inappropriate use of antibiotics in animal feed additives.[27] Table 4.1 shows the major regulations and rules adopted by the Chinese government governing the practice of antibiotics use in food producing animals since 2001.[28]

Table 4.1 Rules and regulations relevant to use of veterinary (antibiotics) medicine

time	Documents	Main objectives	Updated on
2015	The Five-Year Comprehensive Action Plan for Combating the Abuse of Animal (antibacterial) Drugs 2015–2019, CMA, July 20.	Check the rise of antibiotics misuse disciplining the behavior of food animal producers, increasing the government's capacity to monitor and cleaning up the markets for counterfeited and banned drugs.	
2015	Tracing down the liabilities for the quality of veterinary medicine (Announcement 2210, CMA)	Two-dimensional barcode adopted and uploading required product information	
2015	Administration rules for approval numbers of veterinary medicine (CMA Order No.4)	Strengthen administration of approval procedures	Administration rules for approval numbers issued on November 24, 2004 abolished
2013	Administration rules for prescribed and non-prescribed veterinary medicine (CMA Order No. 2)	Strengthen supervision over use of veterinary medicine, prevent inappropriate use and secure product safety	
2012	Decisions on strengthening food product safety (State Council No.20, [2012]	Food product safety	In (9),article 2: improve inspection and quarantine administrations and subsidy policies for harmless disposal

27 <http://www.agri.cn/DFV20/nmg/syjs/yzy/201408/t20140806_4001156.htm>. There it contained the regulations of various countries on the practice of antibiotics in food producing animals.

28 Almost all the No.1 Documents on agricultural development issued by the Central committee of the CCPC mentioned the problem arisen from misuse of antibiotics in China's animal husbandry.

Continued

time	Documents	Main objectives	Updated on
2011	List of banned veterinary drugs and other chemicals for food producing animals （Notice No. 193, CMA）	For safety of animal derived food products	
2010	Quality management practice for veterinary medicine (CMA Order No. 3)	Secure the quality of veterinary medicine	
2005	List of local standards for veterinary medicine abolished (CMA Notice No. 560 号)	Veterinary medicine Standards unification	Notice No. 426
2005	Rules for administering the development of new veterinary medicine（CMA Order No. 55 号）	Maintain high standards for the development new veterinary medicine	
2004	Registration of veterinary medicine （CMA Order No. 44）	Ensure transparent and controllable registration procedures	
2004	Administration rules for approval numbers of veterinary medicine (CMA Order No.45)	Strengthen administration of approval procedures	
2004	Rules for administering veterinary medicine（State Council Order No. 404）	Ensure quality of veterinary medicine	In (1) Article 72, antibiotics in veterinary medicine was specifically mentioned
2003	Administration of labeling and descriptions of veterinary medicine (CMA Order 22)	Standard practice in labeling and describing the functions of veterinary medicine	
2002	Guidelines for the production quality of veterinary medicine (CMA Notice No. 11)	Ensure product quality at critical production stages	
2002	Regulations on the MRL maximum residue limit in animal derived food (CMA No. 235)	Strengthen control over residues	Based on international, European and the US standards
2001	Standard practice for the use of feed additives（CMA Announcement No. 168）	Control abuse of feed additives	

Source: Based on <http://www.ivdc.org.cn/www–old/ and <http://www.agri.cn/>

The government efforts in creating a regulatory framework for the control of antibiotics use in food producing animals may be represented in the following aspects. First, **setting rules and regulations.** After 2001, the Chinese government had adopted a series of regulations and policies to govern the antibiotics use in food producing animals including rules related to animal feed additives, list of drugs banned for use and measures to control drug residues (see Table 4.1). Specifically, in 2001 the Ministry of Agriculture issued *Standard practice for the use of feed additives* (CMA Announcement No. 168) which is effective today (see Table 4.2 and Table 4.3). According to the Announcement

(No. 168), animal feed additives are divided into two categories. The first category contains the veterinary drugs that are allowed to be used as feed additives on a long-term and non-therapeutic basis. However, the producers should indicate on the label "medicine for additive use" for identification purpose. There are 21 antibiotics products among the 31 products in Table 4.2 that are allowed to be used as feed additives. The second category covers the products that may be used as preventives in animal feeds, but subject to the prescriptions by a veterinarian (Table 4.2) and manufacturers are required to indicate on the label "veterinary medicine".

Following the central government, local governments also developed corresponding rules and regulations and, took corresponding actions to supplement the central government's efforts. By the year 2015，the Chinese government allowed 21 antibiotics products to be used as feed additives for food producing animals (see Table 4.2). The government also provided detailed instructions on how and when these antibiotics products may be used and, what precautions users should take.

Second, **strengthening the administration approval procedures.** In addition to rule setting, efforts were also made to strengthen the approval procedure for the use of animal drugs so as to control the use of human medicine for food producing animals, ban unapproved drugs and unify the country's standards. In 2005, the government launched a campaign to crack down on the illegal production of veterinary medicine and abolished the various local standards for the production and use of veterinary drugs.

The third aspect of the efforts made by the government is to standardize the use of animal feed additives. A system of antibiotics prescriptions by professional veterinarians was established and a number of relevant regulations were adopted including *The Administration Rules for Prescribed and Non-prescribed Veterinary Drugs* (2013), *Catalogue of Prescribed Veterinary Drugs I* (2013) *and, Catalogue of Basic Drugs for Rural Veterinarians* (2014). To strengthen the discipline in the use of antibiotics in feed additives, *the Catalogue of Non-therapeutic Use of Feed Additives* adopted in 2008, was updated and the new version *The Catalogue of Animal Feed Additives* was published in 2013. Also measures were taken by the government to standardize labeling and users' instruction manuals and crack down on the practice of using labeling and instruction manuals to mislead the users. The government has also tried to assist in the antibiotics users by providing clear technical guidance such as issuing the list of banned drugs for food producing animals and withdrawal time requirements for different drugs and food producing animals.

Fourth, strengthening the supervision and control on the use of animal medicine especially antibiotics. Until today, the Chinese government has established a rather complete regulatory framework to govern the whole process of antibiotics flows from R&D, approval, production, sales to clinical use. In 1999, China started the supervision program to monitor and control the residue of animal medicine. An average of 14,000 tests was conducted every year covering nine animal food products such as meat, eggs, milk, etc. The tests focused on the effects of 24 antibiotics drugs including ceftiofur, thiamphenicol and macrolides.[29]

In 2008, China started to test AMR with about 3000 tests implemented each year and established an AMR database to help monitor the development of AMR in China.[30] After 2011, the Ministry of Agriculture launched 5 campaigns to crack down on the widespread misuse of

29 In general, these tests indicated that the animal medicine residue had declined every year and in 2009, the residue rate reported as about 0.28 percent. See ASKCI Consulting, China's Antibiotics Markets: An In-depth Analysis and Prospect 2012–2016, 2012 and the press interview by Xu Shixin, February 25, 2016.

30 http://scitech.people.com.cn/GB/13424217.html

antibiotics in food producing animals. In 2014, the Ministry issued the Announcement (CMA No. 2071) *More Severe Punishment for Illegal Use of Animal Drugs.* The Announcement had identified six types of violations and stated clearly the kind of punishment that the violators would receive for the behavior. In September 2015, the government banned 4 fluoroquinolones drugs which had been used by both humans and animals including lomefloxacin, ofloxacin Pefloxacin and norfloxacin.

In 2008, China started to test AMR with about 3000 tests implemented each year and established an AMR database to help monitor the development of AMR in China.

Throughout 2016, the Ministry of Agriculture took actions to crack down on the misuse of antibiotics in fishing.[31] The main targets of the campaign focused on antibiotics overuse, non-compliance with drug withdrawal time and illegal use of banned amantadine and ribavirin.

Measures were also taken by the government to discipline the use of antibiotics in food producing animals including cracking down on unapproved drugs, training the farmers on how to use veterinary drugs, providing technical assistance in establishing record files for the use of veterinary drugs by the food producing animals and strict enforcement of drug withdrawal time requirements

The government issued the *Regulations on the maximum limit of drug residues in animal derived food* (CMA No. 235) in 2002. By 2012, it had published the standards for testing 145 residues and was capable of testing about 150 product varieties.[32]

China issued the Regulations on the maximum limit of drug residues in animal derived food in 2002. In September 2015, the government banned 4 fluoroquinolones drugs which had been used by both humans and animals including lomefloxacin, ofloxacin Pefloxacin and norfloxacin.

Table 4.2 Standard practice in using pharmaceuticals in animal feeds

To be added	To be added	To be added	To be added
1. Dinitolmide Px.	10.Amprolium Hydrochloride and Ethopabate Px.	19. Monensin Sodium Px*.	28.Oregano Oil Px.
2. Madummicin Ammonium Px*.	11.Amprolium Hydrochlofide、Ethopabate and Sulfaquinoxaline Px*.	20.Baeitmcin Zinc Px*.	29.Bacitracin Zinc and Colistin Sulfate Px*.
29.Bacitracin Zinc and Colistin Sulfate Px.	12.Clopidol Px.	21.Flavomycin Px.	30.Oxytetracycline Calcium*
4.Nicarbazinand Ethopabate Px.	13.Hainamnycin Sodium Px*.	22.Virginiamycin Px*.	31.Kitasamycin Px*.
5.Narasin Px*.	14.Semdummicin Sodiuln Px*.	23.0laquindox Px.	32.Chlortetracycline (FeedGrade) Px*.
6.Narasinand Nicarbazin Px*.	15.Diclazuril Px*.	24.Nosiheptide Px*.	33.Enmmycin Px*.

31 China has never allowed use of antibiotics as growth promoters for fishing.

32 According to an interview of a Chinese expert Xu Shixin with the press on February 25, 2016, China's maximum residue limit (MRL) was mainly based on the standards proposed by FAO Codex Alimentarius Commission (CAC) with some reference to the standards adopted in the US and EU. On average, 302 MRL indicators were identical to the standards proposed by the CAC and 8 indicators had lower MRL standards. As a result, China's MRL equivalence with CAC standards was about 98 percent.

Continued

To be added	To be added	To be added	To be added
7.Lasalocid Sodiulll Px*.	16.Compound Sodiuln Nitrophenolate Px.	25.Avilamycin Px*.	
8.Halofuginone Hydrobromide Px.	17.Arsanilic Aeid Px.	26.Salinomycin Sodiulll Px*.	
9.Robenidine Hydrochloride Px.	18. Arsanilic Acid Px.	27. Colistin Sulfate Px*.	

Source: Notice on the Standard Practice in Using Pharmaceutical Additives in Animal Feeds, CMA [168], No. 20, 2001.

Notes: Starred "*" indicates antibiotics ingredient. "Px." means Premix.

Table 4.3 List of veterinary drugs used preventives in animal feeds (prescriptions required)

34.Sulfaquinoxaline and Diaveridine Px*.	40.Lincomycin Hydroehloride Px*.	46.Flubendazole Px.	52.Thiamphenicol Powder*
35.Destomycin A Px*.	41.Sedeeamycin Px*.	47.Compound Sulfadiazine Px.	53.Norfloxacin Berberine Hydroehloride Px.
36.Hygromycin B Px*.	42.Ivermectin Px*.	48.Lincomycin Hydroehloride and Spectinomycin Sulfate Px.	54.Magnesium Ascorbic Acid Phosphate and Ciprofloxaein Hydroe NOdde Px*.
37.Dimetridazole Px.	43.Nifurstyrenate SodinIn Powder	49.Neomycin Sulfate Px.	55.Ciprofloxacin Hydroehloride and Berberine Hydroehloride Px*.
38.Tylosin Phosphate Px*.	44.Tiamulin Fumarate Px*.	50.Tilmicosin Phosphate Px.	56.Oxolinic Acid Powder
39.Apmmycin Sulfate Px*.	45.Cyromazine Px*.	51.TylosinPhosphate and Sulfamethazine Px.	57.Sulfachiloropyrazine SOdiHal Soluble Powder*

Source: Notice on the Standard Practice in Using Pharmaceutical Additives in Animal Feeds, CMA [168] No. 20, 2001.

Notes: Starred "*" indicates antibiofics ingredient. "Px." means Premix.

With the increased public concern about the negative impact of antibiotics on health and the country's deteriorating situations, the Ministry of Agriculture issued a comprehensive five-year action plan (2015–2019) to check the problem by disciplining the behavior of food animal producers, increasing the government's capacity to monitor and cleaning up the markets for counterfeited and banned drugs in July 2015 (see Table 4.1). The plan promised that the percent of pass for both antibiotics drugs and food producing animal products qualified for the MRL standards would reach 97 percent by the end of 2019. The action targeted important production areas and products with the focus on eliminating the use of unapproved drugs, counterfeited drugs, misleading labeling and descriptions and illegal use of antibiotics in animal feed additives. Large food producing animal farms areas, large aquatic farms, suppliers of animal drugs (including retailers and manufacturing firms), suppliers of animal feeds, pharmacies of veterinary station in rural areas and veterinarians were singled out for intensive investigation.[33]

33 For details, see Ministry of Agriculture (2015) The Five-Year Comprehensive Action Plan for Combating the Abuse of Animal (antibacterial) Drugs 2015–2019, July 20.

The 2015 action plan promised that the percent of pass for both antibiotics drugs and food animal products qualified for the MRL standards would reach 97 percent by the end of 2019.

However, the measures described above had mainly focused on the enforcement of existing China's laws and regulations. In view of the widespread use of antibiotics in animal feeds as growth promoters and lack of confidence by the general public, there are still some critical issues that need to be tackled in China. So far, in contrast to EU which imposed a blanket ban on the use of antibiotics as growth promoters on a precautionary principle in 2006[34], the Chinese government has been trying to seek a compromise over the use and not use of antibiotics in animal feeds for non-theupeufic purpose.[35] In many ways the level of China's restriction is similar to that of the US. The Chinese regulations allowed use of antibiotics in food producing animals for growth promoting and prophylactic purpose, but limit the scope of use within an approved list by the government authorities.[36]

In contrast to EU which imposed a blanket ban on the use of antibiotics as growth promoters on a precautionary principle in 2006, the Chinese government has been trying to seek a compromise over the use and not use of antibiotics in animal feeds for non-therapeutic purpose.

A second important issue is that, as China's animal farming is highly decentralized with small-scale farming accounting for over 70 percent of the total production, enforcement and monitoring are extremely difficult. So far, the government actions to eliminate the misuse of antibiotics in animals could only reach large-scale producers and antibiotics manufacturers. The third issue is related to the second. Given China's size and highly decentralized model of production, monitoring the use of antibiotics in animals is a formidable task. To secure the safety of food animal products and increase the confidence of the world on the quality of the Chinese production, it is imperative to consider using third party institutions both at home and

34 On March 15, EU's AGRI committee approved an amendment by Michel Dantin to ban the importing of food-producing animals and their products which had received medicated feed containing antimicrobial veterinary medicinal products in order to prevent disease.

35 The approach adopted by the Chinese authorities to use of antibiotics as animal growth-promoters is justified by the argument made by some unconvinced experts of the field. For example, Wallinga and Burch (2013) believed that the doses of antibiotics used for this purpose are small compared to their therapeutic doses and it is not definitely known whether such low doses really select for resistance or not. Turnidge (2004) believed the possibility of AMR having a major impact on human health minimal. There are also experts who believed that the restrictions on antibiotics use in animals may lead to an overall deterioration in human health as other sources of disease may emerge, partly due to unhygienic living conditions for food producing animals. A Chinese expert Professor Feng Dingyuan believed that, in interview with media on September 17, 2014, the positive effect of modest use of antibiotics as preventives and growth promoters could outweigh the negative effect (http://www.chinairn.com/news/20140917/14445925.shtml). According to Chen Daijie, deputy director of China Research Institute of Medical Industry in an interview with China Medical Report on Feruary2, 2010, around 100,000 tons of antibiotics was used as growth promoters in China each year.

36 The US has basically adopted the "Principle of Proof" approach to use of antibiotics in animal feeds as growth promoters. According to the Guidelines for Industry issued by the Center for Veterinary Medicine under the US Food and Drug Administration (2012), antibiotics only for the prevention, control and treatment of infections in animals were allowed, while that for growth promoting and increasing efficiency were not recommended. Additionally, use of some antibiotics of critical importance (e.g., the third generation of cephalosporins) was reserved only for use in humans. The suppliers of antibiotics products were required to label their products voluntarily the disapproval for the use of antibiotics as growth promoters in animals and the products have been supervised by a veterinarian.

abroad to help monitor the use of antibiotics in animals and assess the potential risks. It is a difficult decision on the part of the government and even general public with strong nationalistic sentiment, but it will help make China's production more transparent and turn China to be a global leader on the AMR issue.

Given China's size and highly decentralized model of production, monitoring the use of antibiotics in animals is a formidable task. To secure the safety of food animal products and to increase the confidence of the world on the quality of the Chinese production, it is imperative to consider using third party institutions to help monitor the use of antibiotics in animals and assess the potential risks.

The above discussions show that the government has relied heavily on periodic campaigns to eliminate the antibiotics abuse in the animal husbandry. China's production of food producing animals is highly decentralized, with small farms accounting for 70 percent of the country's total output and confronted with a wide array of abuses including overuse, misuse, use of banned, animal use of human drugs, counterfeiting and misleading labeling and descriptions. In this circumstance, the problem of ineffective control by the government agency is evident. China has a highly centralized governance structure in the administration of veterinary drugs. The widespread problems essentially reflect the under-supply of public services such as monitoring, enforcement and identification of potential risks. The present system has monopolized almost all aspects of veterinary drug administration and while other social institutions face high entry barriers to supply relevant services to the public, despite the fact that responsible government agency encounters the difficulty of inadequate staff and shortage of technologies. One way to solve the problem is to allow third-party institutions at home and abroad to participate in the administration of the market.

Ⅴ. Economic Implications of Antibiotics Misuse

Much concern of the world about the misuse of antibiotics is the emergence of antimicrobial resistance (AMR).[37] According to the World Health Organization (WHO) definition, AMR develops when microorganisms such as bacteria no longer respond to antibiotics to which it was originally sensitive. The implication is that traditional treatments no longer work as infections become impossible to control and the world is facing increased risk of unnecessary deaths (Adiningrat 2015).

A number of attempts have been made to estimate the human and economic costs of AMR. According to O'Neill et al (2014), there were 700,000 deaths world-wide each year. By 2050, 10 million people may die per year if resistance continued to rise and Asia would have the highest mortality rate with 4,730,000 deaths. So between now and 2050, around 300 million people are expected to die prematurely and the total GDP loss would be USD 100 trillion (USD 210 trillion including the secondary effects).[38] This estimate was based on two scenarios modeled by Rand Europe and KPMG. Specifically, Rand Europe calculated how the variables listed below might affect the production function:

–Increased mortality or deaths attributable to AMR;

–Increased morbidity;

–Indirect costs.[39]

The KPMG had followed the four stages to estimate the impact of AMR on the global economy:

–estimate the current health costs associated with AMR;

37 There are also concerns about other negative effects of antibiotics use, but mainly related to inappropriate use, such as destruction of immune system of animals, damage on human health and deteriorating ecosystem. It is believed that long-time use of tetracyclines, neomycin, kanamycin and gentamycin could lower or destroy the immune capability of food producing animals. The case of hundreds dead pigs floating down along the Huangpu River in Shanghai in 2013 was often used an example of the outcome of misuse of antibiotics in animals in China. In addition, some antibiotics (e.g. sulfamethazine, streptomycin etc.) could enter into human bodies causing toxic side effects while some antibiotics used by animals have the potential risk of inducing carcinogenesis, teratogenesis and mutagenesis. If humans consume meat, eggs and milk products that contain these antibiotics, they were more susceptible to the lesion. Finally, antibiotics residues can enter into waters and soil through release of urine and feces, causing damage to human health.

38 The Rand Europe scenario was based on the assumption that if AMR rates rose to 100 percent what would be the costs, while holding the number of cases of infection constant. The KPMG scenario modeled what would happen if AMR rose by 40 percent from today's levels and the number of infections double as a result of people being infected longer, causing more transmission.

39 Indirect costs are mainly the opportunity costs covering the costs of trying to avoid the medical procedures, or travelling to other safe places or trading food products when people are faced with higher AMR risks.

–evaluate the potential future AMR scenarios;

–estimate the potential impact AMR on productivity;

–predict long-term economic growth under the different AMR scenarios.

There are also estimates about the damage in China. An estimate released at a nation-wide Training Program on Clinical Use of Antibacterial Medicine for Grassroots-Level Medical Institutions held on January 9, 2009 suggested that there were about 80,000 deaths attributable to misuse of antibiotics and medical costs related increased by 80 billion *Yuan* each year in China.[40] Another estimate by O'Neil (2014) projected that 1 million people might die of AMR per year and cumulative economic costs would reach USD 20 trillion by 2050.

This study focuses on the economic implications for China's food producing animal industry. In the following discussions, we first briefly analyze the welfare distributions of inappropriate use of antibiotics and then, results of a numerical exercise are presented to demonstrate the possible loss in China's food producing animal industry if China were to suffer a major AMR shock.

Distorted incentive structures and marginal damage tax

In the antibiotics market, the price of antibiotics is set at a socially distorted level as manufacturers take into account their private costs only in the decision making while ignoring the social costs. Consequently, motivated by maximum profits, antibiotics manufacturers would have the incentive to produce antibiotics beyond socially optimal level, causing damage to the society. As the market price is below socially optimal level, the consumers would benefit from consuming the products at low prices in economic terms. However, if we assume that antibiotics are a bad good, the overconsumption would cause damage to the welfare of consumers.[41] The loss of consumer benefits in China's antibiotics market is mainly derived from the fact that because the price of antibiotics is far below the socially optimal level, the consumers with imperfect information about the quality of meat and poultry products tend to over-consume the antibiotics contained in these products, resulting in antimicrobial resistance (see Appendix 2 for detailed analysis).

In the antibiotics market, the price of antibiotics is set at a socially distorted level as manufacturers take into account only the private costs only in the decision making while ignoring the social costs

The loss of consumer benefits may be divided into two parts. The first part of the loss is born directly by consumers through consumption of antibiotics contaminated food such as meat and poultry products. This constitutes the net loss to the society. Another part of the consumer loss is transferred implicitly to the producers as producer benefits as they are exempted from paying for the damage caused by the inappropriate use of antibiotics. But the manufacturer's gain is exactly the consumers' loss and there is not net loss to society. This loss of consumers' welfare may be called as producer's neglect. A conclusion we can draw from the analysis is that in the antibiotics market, the consumer loss consists of two parts: the net loss to the society and the loss related to producer's neglect.

40 The estimates were made for the year 2005.

41 There have been different estimates about the costs that consumers may suffer (e.g. O'Neill). As described above, these costs incurred by consumers mainly include deaths attributable to inappropriate use of antibiotics, prolonged periods of sickness and indirect costs depending upon the difference in definitions. In this analysis, no attempt is made to define exactly what the consumer loss would include and the focus is to examine the welfare effects of antibiotics use.

The loss of consumer benefits in the antibiotics market is mainly derived from the fact that because the price of antibiotics is far below the socially optimal level, the consumers with imperfect information about the quality of meat and poultry products tend to over-consume the antibiotics contained in these products, resulting in antimicrobial resistance.

Another important feature is that as the antibiotics manufacturers receive above socially optimal return without paying for the damage caused, they have the strong incentive to oversupply the antibiotics to the market. On the other hand, as consumers consume cheap antibiotics products without paying for the implicit costs for the health, overconsumption is inevitable. So in an unregulated market, firms overproduce antibiotics to the market and consumers over-consume because the low market price provide incentives for such behaviors.

In an unregulated market, firms overproduce antibiotics to the market and consumers overconsume because the low market price provide incentives for such behaviors.

A solution to the above problems is for the government to impose a tax which is equal to the marginal damage caused by antibiotics producers. This would force the producers to set the production at a socially optimal level. The marginal damage tax could also increase the market price to induce the consumers to use antibiotics more rationally.

A marginal damage tax would force the producers to set the production at a socially optimal level and induce the consumers to use antibiotics more rationally.

Direct loss in animal husbandry industry

Finally, let's look at the impact on China's animal farming if there was major AMR crisis in the country. Conceptually, an AMR crisis in the form of massive deaths of humans and animals and, widespread morbidities for both could cause a major loss in domestic animal farming and sharp rise in imports. Particularly important for China, the long advocated policy of national security of food supply would suffer a serious setback (see Appendix 3 for detailed analysis).

An AMR crisis in the form of massive deaths of humans and animals and, widespread morbidities for both could cause a major loss in domestic animal farming and sharp rise in imports. Particularly important for China, the long advocated policy of national security of food supply would suffer a serious setback.

Table 5.1 shows China's export, import and total output of animal farming. It suggests that China had steadily increased its production and trade in this industry. By 2014, China exported USD25.3 billion of food producing animal products and imported USD20.2 billion. The output of animal husbandry industry (not including aquaculture) reached 2.9 trillion *Yuan* (equivalent to USD 482.6 billion).

Table 5.1 China's animal farming, export, import and output

	Export, animal farming including fishing (USD100 million)	Import, animal farming including fishing (100 million)	Output, animal farming (100 million *Yuan*)	Output, aquatic (100 million *Yuan*)
2005	101	42	13311	4016
2006	116	46	12084	3971
2007	122	60	16125	4458
2008	131	72	20584	5203
2009	129	67	19468	5626
2010	165	92	20826	6422
2011	210	125	25771	7568
2012	224	138	27189	8706
2013	236	181	28435	9635
2014	253	202	28956	10334

Source: UN ComTrade.

Note: food animal products cover the products under HS code: HS01, HS02, HS03, HS04, HS0504 and HS 16.

Table 5.2 shows the output for meat, eggs, milk and aquatic products in physical tons from 2005 to 2014. It provides a different picture about China's animal farming from that presented in Table 5.1. In physical terms, China's output of these products fell relative to that in 2005. Table 5.3 shows China's population in aquaculture and animal husbandry. In 2014, China had a population of 14.29 million in fishing in 2014 and 17.05 million in animal husbandry.

The direct output loss in China's animal husbandry industry would be 467 billion *Yuan* at minimum.

To predict the direct loss in China's animal husbandry, we use similar (but less serious) historical precedent-SARS (severe acute respiratory syndrome) that occurred in 2003 in China as the reference for the estimate (see Appendix 3 for details). Assume that there is a full-blown AMR crisis. The sector that was directly affected by SARS was poultry production. Using the rate of change (reduction or increase) in domestic poultry meat production (–11 percent), poultry exports (–10.2 percent) and poultry imports (+28.2 percent) immediately after the outbreak of SARS, and relevant data in 2014, the estimated results show that the direct output loss would be 467 billion *Yuan* at minimum and the loss in exports for China's animal husbandry would be no less than 16 billion *Yuan*.

It is a conservative estimate as it is generally believed that a full-blown AMR crisis would be much more serious (O'Neil et al 2014). However, the results are sufficient to warn the policymakers that the actual damage to China's animal husbandry industry as well as the whole society could be much worse. Note also that while the estimated loss is conservative, it far exceeds 30 billion *Yuan* to 40 billion *Yuan* loss in China's animal husbandry industry based on a statement by an anonymous official from China Ministry of Agriculture.

Table 5.2 Output of China's animal farming (10,000 tons)

	Meat	Eggs	Milk	Aquatic products
2005	8706.74	2893.89	3724.64	6461.52
2006	8535.02	2876.06	3531.42	6172
2007	8387.24	2861.17	3743.60	5907.68
2008	7965.10	2811.42	3657.85	5603.21
2009	7925.83	2762.74	3575.62	5373.00
2010	7649.75	2742.47	3518.84	5116.40
2011	7278.74	2702.20	3555.82	4895.60
2012	6865.72	2528.98	3525.24	4747.52
2013	7089.04	2424.00	3193.41	4583.60
2014	6938.87	2438.12	2753.37	4419.86

Source: UN ComTrade.

Table 5.3 Population in aquaculture and animal husbandry (10,000 people)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
渔业	1290.2	1259.5	1316.9	1454.4	1384.7	1399.2	1458.5	1444.15	1443.2	1429.0
牧业	1646.0	1652.3	1655.3	1579.1	1618.1	1708	1688.4	1638.3	1704.9	

Source: China Aquaculture Statistical Yearbook and China Animal Husbandry Statistical Yearbook.

Appendix 1
Welfare Distributions of the Negative Effects of Antibiotics Misuse

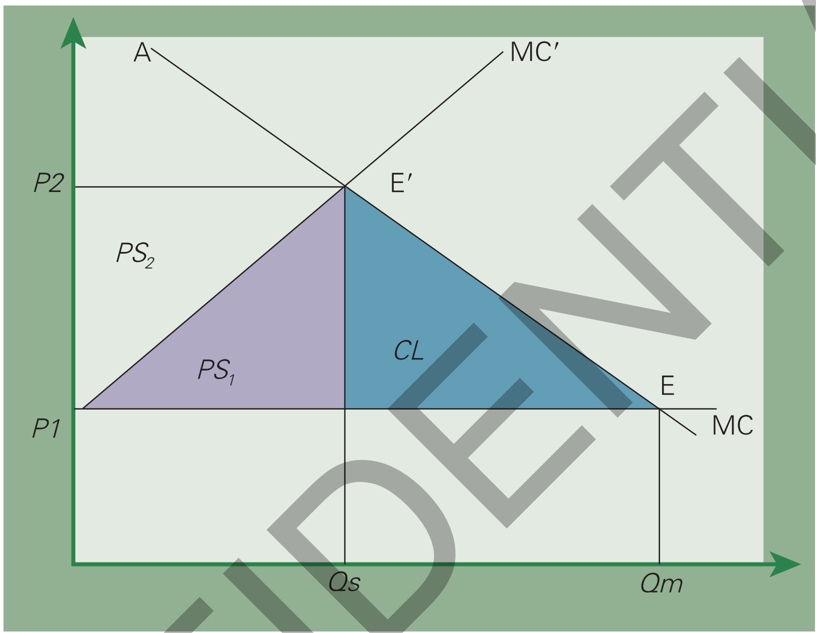
The market for antibiotics used in food producing animals is a two-tier market. In the firs-tier market, there are food animal producers who buy antibiotics products as treatment medicine and feed additives (including preventives) as inputs for their food animal production. On the supply side of this market there are manufacturers (retailers) of antibiotics products who sell directly to the food animal producers for productive use. In the second-tier of the antibiotics market, there are food animal producers and final consumers. Food animal producers sell their meat and poultry products to the final consumers. However, their products generally contain antibiotics, misuse of which may lead to drug-resistant strains. The final consumers do not buy antibiotics directly. Instead, they consume antibiotics indirectly though their consumption of food animal products such as meat and poultry. In this analysis, the focus is to examine the welfare distributions induced by the use of antibiotics. It is assumed that the final consumers constitute the demand side of the market. As the manufacturers and food animal producers all supply antibiotics to the final consumers of meat and poultry goods, though in a different way, it is assumed, for the sake of simplicity, that antibiotics manufacturers (including retailers) and animal food producers act jointly as the supplier of antibiotics in the market.

Suppose that the firm producing antibiotics has constant marginal cost. The initial market equilibrium is at point E. At this point, Qm quantity of antibiotics is produced and supplied at market price P_1. The friangle AP_1E represents consumer benefits (consumer surplus) if the damage effects of antibiotics are ignored. The consumer benefits mainly come from the low market price for antibiotics. However, in the production process, the antibiotics manufacturers consider only its private cost of production. Consequently, overproduction is inevitable. As the market price is low, over consumption of antibiotics would also occur. But production of antibiotics is causing damage to the society. Suppose the antibiotics supplier is causing a marginal damage of MD, the social marginal cost of producing antibiotics should be MC′=MC+MD. If the firms took social damage into account, the actual production should take place at E′, with a higher price P_2 and lower quantity Qs. So in a unregulated market, the firm overproduces antibiotics to the market and consumers over-consume as the low market price provide incentives for such behaviors.

The figure shows that in an unregulated market, the consumers would suffer an implicit loss of CL in consumer benefits due to inappropriate consumption of antibiotics while the manufacturers would gain the area PS. But the manufacturers’ gain is taken from the consumers in that it has not paid the consumers for the damage and may be called as producer’s neglect.

The above analysis indicates that a tax equal to the manufacturers’ marginal damage should be imposed. As a result, the producer would produce less and the market price would be higher which would check the consumer demand for excessive use of antibiotics.

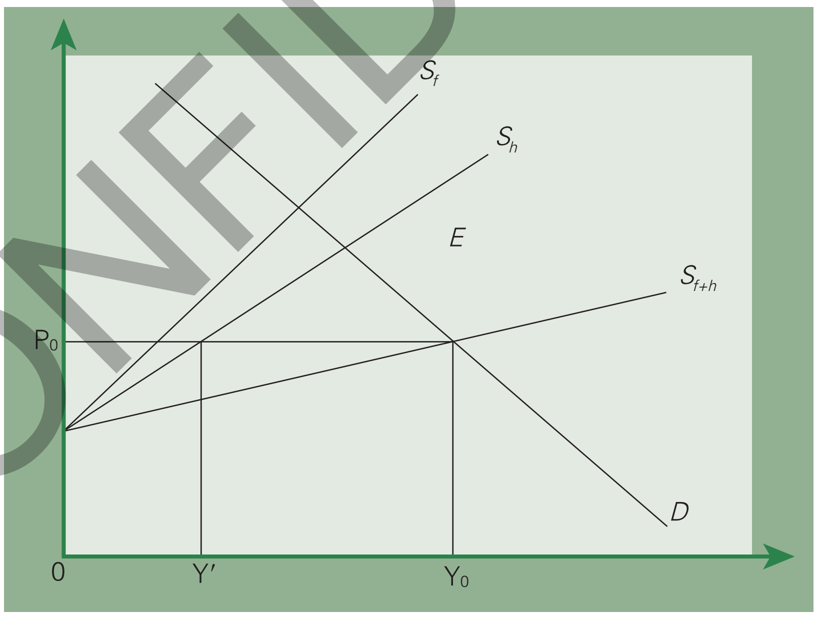
In summary, the analysis shows that as producers do not pay for the damage caused by the overuse of antibiotics, they tend to over produce the product. With the low market price the consumers tend to overuse. Consequently, consequently, the consumers would suffer a loss in benefits. Part of the consumers' loss is transferred to the producers as benefits as they are exempted from paying for the damage caused by the inappropriate use of antibiotics. If government imposed a tax equal to the marginal damage, the producers would try to set the production at an socially optimal level. The damage tax would increase the market price and would force the consumers to use antibiotics more rationally.



Appendix Figure 1.1 Welfare distributions of antibiotics misuse

Appendix 2
An Economic Analysis of AMR Shock to Demand for Food Animal Product

In this analysis, we examine the effect of a major AMR shock on a country's domestic demand for meat and poultry products. Figure 2 shows a simple analytical framework of supply and demand. D represents pre-shock total domestic demand for meat and poultry products. S_f represents foreign supply of meat and poultry products while S_h is the domestic supply of the products. With the transport costs, domestic support and import controls, it is assumed that the foreign supply of meat and poultry products has a higher cost in the domestic market and thus, is above the home supply curve. Domestic total supply S_{f+h} is the horizontal summation of S_f and S_h curves. Initially, domestic equilibrium is at point E with Y_0 level of output demanded at price P_0. At this equilibrium, domestic producers supply 0–Y′ output to the market while the remaining gap Y′–Y_0 is filled in by the imports from the rest of the world.



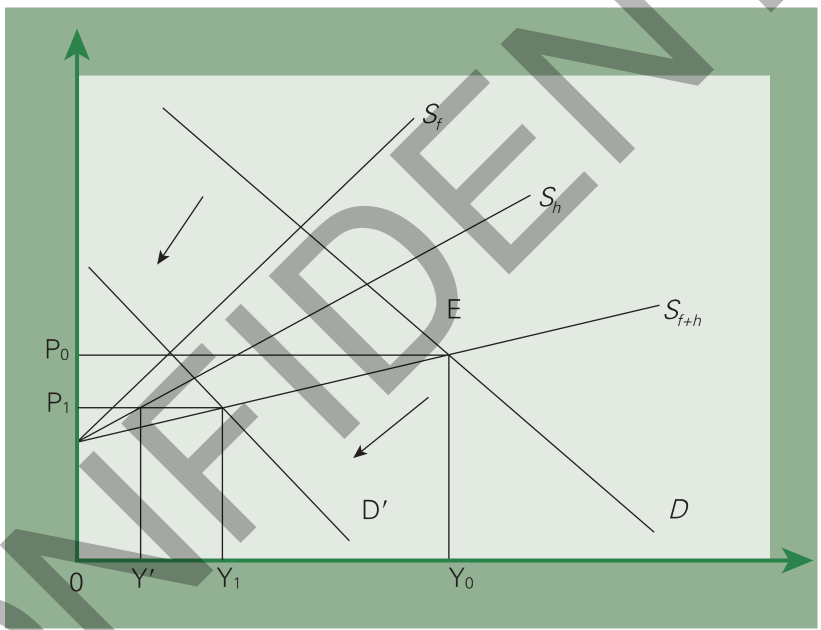
Appendix Figure 2.1 Domestic market equilibrium for food animal products

Suppose a major AMR shock occurred in the country in the form of massive deaths of animals and humans through inappropriate consumption of antibiotics. The immediate impact of the shock is to cause a panic among the individual consumers. The consumers may respond to the shock differently depending upon the circumstances. In an extreme case, they may give up consuming all meat and poultry products for fear of contaminations. In this case, domestic demand for food animal products would become zero. Consequently, domestic production of food producing animals would shut down and foreign exports to the domestic market would come to a full stop.

In another case, which may be more normal, the consumers may substantially cut down the consumption of domestic-produced food animal products and switch to imports. As a result, demand for domestic meat and poultry products would drop drastically while the demand for antibiotics-free foreign products that come from high-standard countries may increase substantially. This would lead to serious consequences for the domestic production as unemployment would rise and security of food supply would be under threat in addition to the massive deaths of humans and animals.

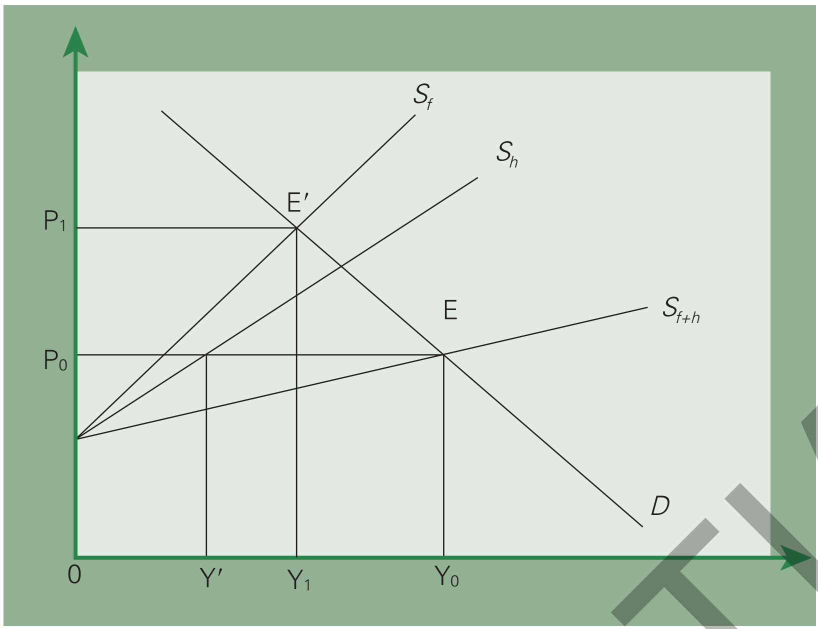
The second scenario is illustrated in Figure 2. With the AMR shock, domestic demand for food animal products shifted down and to the right from D to D′. Domestic price would drop from P_0 to P_1 and total domestic demand for meat and poultry products would decline from Y_0 to Y_1. The home supply of food animal products would shrink to Y′ with the rest of the demand being met by foreign imports.

This analysis indicates that if there was major AMR shock to a country, domestic food animal production would incur a major loss. In the case of China, the long advocated policy of national security of food supply would suffer a serious setback.



Appendix Figure 2.2 Effects of a major AMR shock on domestic food animal production (1)

In the third scenario, with the AMR shock, domestic demand for food animal products would remain constant. However, the structure of the domestic demand may change. Domestic consumers may refuse to consume domestic goods and switch fully to the imported meat and poultry products. Consequently, domestic market price would rise sharply from P_0 to P′. Foreign food animal producers would supply to the whole domestic market at E′ and animal husbandry industry would shut down. In whatever case, domestic food animal producers would suffer heavy losses or even experience shutdown crisis.



Appendix Figure 2.3 Effects of a major AMR shock on domestic food animal production (2)

Appendix 3

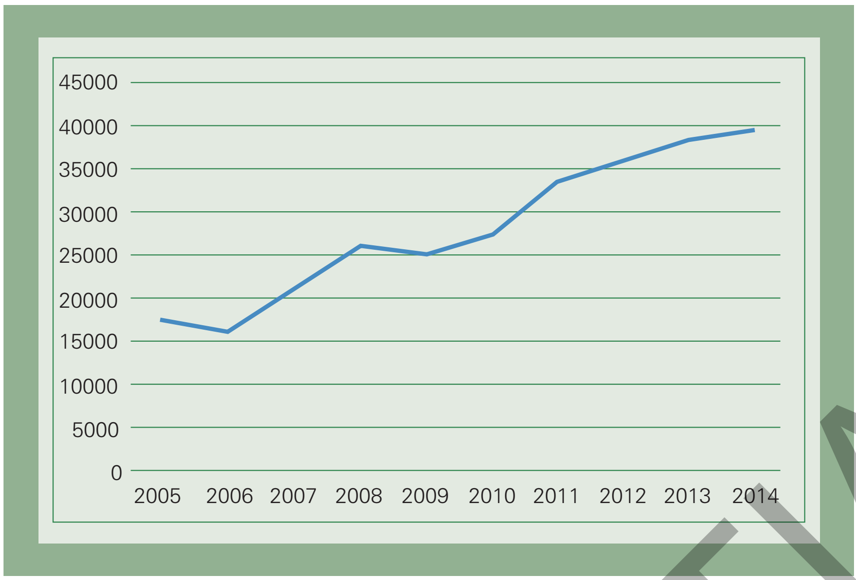
Conservative Estimate of Direct Loss in Animal Husbandry Industry By a Major AMR Shock

In this analysis, we attempt make a conservative estimate of the loss that China's animal husbandry industry might incur if there is a full-blown AMR crisis. The loss to the industry may involve direct loss such as output (or employment) and deaths of humans, loss in relative industries such as antibiotics, feeds for food-producing animals, rising medical expenses, exodus, etc.). Accurate estimates are constrained by the availability of data. Another difficulty is that it is not known how the economy or society would be affected by a full-blown public health crisis, making the projection of the loss an extremely challenging task. Some studies have indicated that the results could be disastrous (e.g. O'Neill et al (2014) while others believed that the loss would be modest, in the neighborhood of 30 billion Yuan to 40 billion Yuan for China's animal husbandry industry.[42]

The analysis in this appendix is an exercise to provide a conservative estimate of the possible loss in China's animal husbandry industry. The estimates focused only on direct costs to the industry ignoring the indirect costs. The estimated results are sufficient to warn the policymakers that the actual damage to China's animal husbandry industry as well as the whole society could be much worse than described here.

Figure 3.1 shows the output of China's food animal farming (including aquaculture) from 2005 to 2014. It has followed an upward trend though with some fluctuations. In 2014, total output reached 3.93 trillion Yuan (or roughly USD644.1 billion. Figure 3.2 shows China's imports of meat, poultry and aquatic products. From 2005 to 2014, China's total import of these products increased from USD4.2billion to USD.20.2 billion. In recent years, China's meat, poultry and aquatic products saw more rapid increase, especially between 2009 and 2011 (Figure 3.3). Before 2009, China's exports of these products stagnated around USD12.0 billion. After 2009, the exports growth started to accelerate until 2011. In 2014, total exports of meat, poultry and aquatic products reached USD25.3 billion dollars.

42 Statement by an anonymous official from China Ministry of Agriculture.

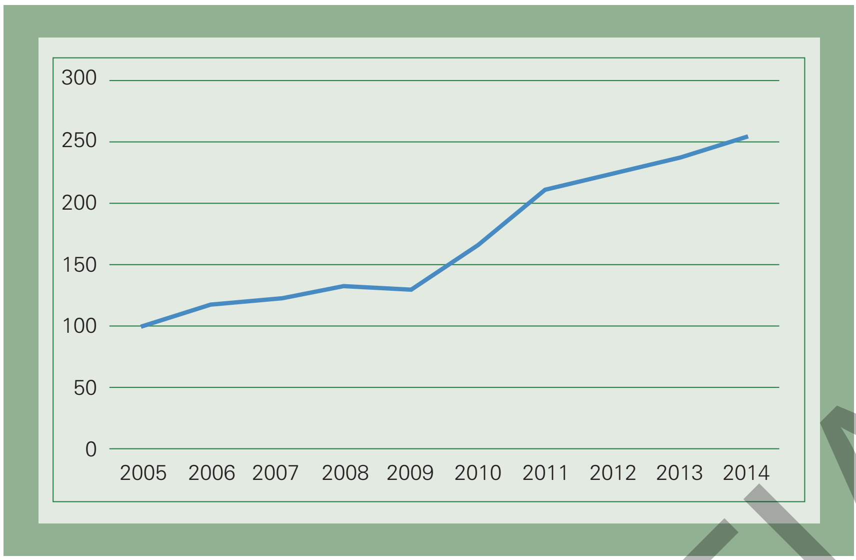


Appendix Figure 3.1 Output of china's animal husbandry and aquatic farming

Source: *China Statistical Yearbook for Animal Husbandry Industry; China Statistical Yearbook for Aquaculture.*

Appendix Figure 3.2 China's imports of meat, poultry and aquatic products

Source: *China Statistical Yearbook for Animal Husbandry Industry; China Statistical Yearbook for Aquaculture.*



Appendix Figure 3.3 China's exports of meat, poultry and aquatic products

Source: China Statistical Yearbook for Animal Husbandry Industry; China Statistical Yearbook for Aquaculture.

1. Full-shutdown scenario

In this scenario, it is assumed that if there was a major AMR shock within the country causing a full-blown public health crisis, consumers may stop consuming home-produced meat, poultry and aquatic products and turned to consume imported substitutes. The scenario also assumes that foreign countries imposed a full ban on the Chinese exports of meat, poultry and aquatic products at the same time.

Under this scenario, domestic production would drop to zero and domestic producers would bear the major part of the total loss (refer to Figure 3.4 in Appendix 2). Domestic consumers may substitute to other non-contaminated home-produced food. If this is the case, domestic producers that produce substitutes (other non-contaminated food) may benefit. However, for the society as a whole, the gains of the producers that produce domestic substitutes would be, depending upon the extent of the substitution, offset by the loss incurred by the food animal producers. In this analysis, it is assumed that domestic consumers would not make any such substitution to other home-made food products.

There are two major effects on the domestic consumers. Assume that consumers' spending on meat, poultry and aquatic products remain unchanged, but the composition of total spending would change in response to ARM shock. For fixed domestic spending, demand for domestic goods would drop to zero as described above, while demand for imported goods would rise sharply. The second effect on consumers is that AMR shock may cause the prices of meat, poultry and aquatic products to rise in the domestic market and consumers would suffer a loss in their welfare because they have to pay more the consumption. However, for the sake of simplicity, this effect on consumer welfare is ignored in the analysis. To include this would only increase the total loss of the economy. The loss estimated below includes only the loss of domestic output in that they would switch to imported foreign goods.

2014 data in *China Statistical Yearbook for Animal Husbandry Industry; China Statistical Yearbook for Aquaculture* is used for the estimate. As export is a part of total domestic products, it is excluded from the calculation.

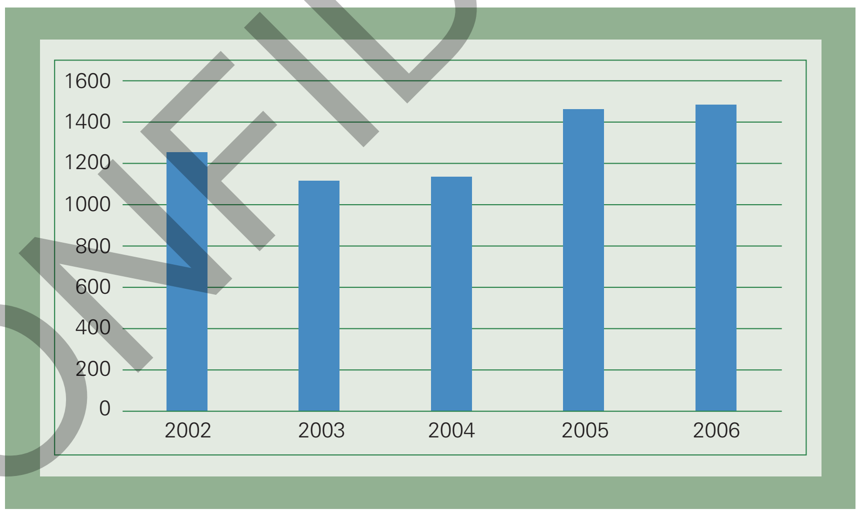
In this scenario, the estimated results show that the immediate loss of China's animal husbandry is estimated to be 3.93 trillion *Yuan* (or USD644.1 billion). China's export loss would be 154.4 billion *Yuan* (or USD 25.3 billion). To meet the domestic demand, China would have to import at least 3.7 trillion *Yuan* (USD600 billion) of meat, poultry and aquatic products.

2. SARS Scenario

As AMR shock has not occurred, it is hard to predict the loss to China's animal husbandry. In this analysis, we use similar (but less serious) historical precedent-SARS (severe acute respiratory syndrome) that occurred in 2003 to infer the possible costs to China's animal husbandry industry if there is a full-blown AMR crisis.

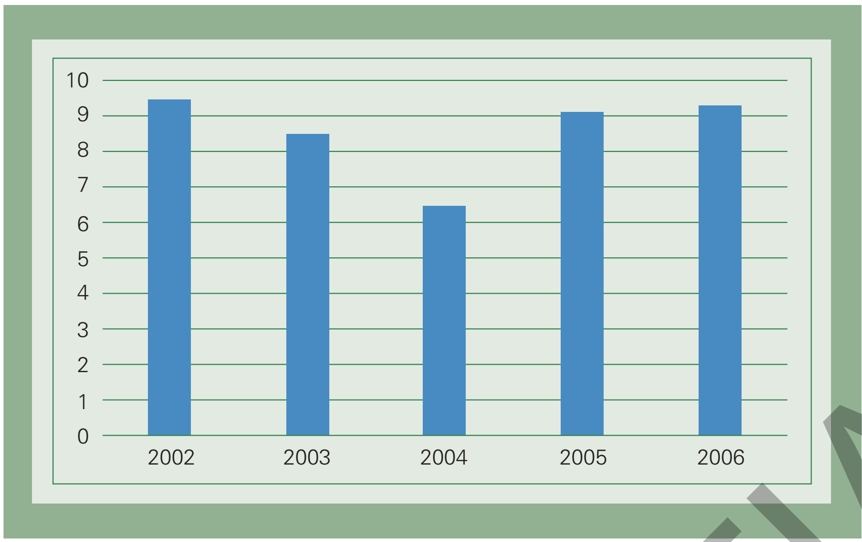
SARS broke out across most parts of China around February 2003. The sector that was most vulnerable and thus directly affected by SARS was poultry production. In this analysis, we use the impact of SARS shock as the benchmark to infer the loss that a full-blown AMR crisis may cause to China's animal husbandry industry. It is generally believed that a full-blown AMR crisis would be much more serious than that of SARS (O'Neil et al 2014). So the estimated loss in this analysis really corresponds to an optimistic prediction.

Figure 3.4 shows China's output of poultry meat from 2002 to 2006. Due to data limitation, the data does not include eggs and live poultry. After the SARS blow in 2003, the output of poultry meat in China dropped by 11 percent. Figure 5 is China's poultry meat export. After the outbreak of SARS in 2003, China's exports of poultry meat dropped by 10.2 percent and in 2004, with the spread of "bird flu" , the exports continued to fall by 23 percent as compared to 2003. In contrast, after the SARS shock in 2003, China's imports of poultry meat surged by 28.2 percent.



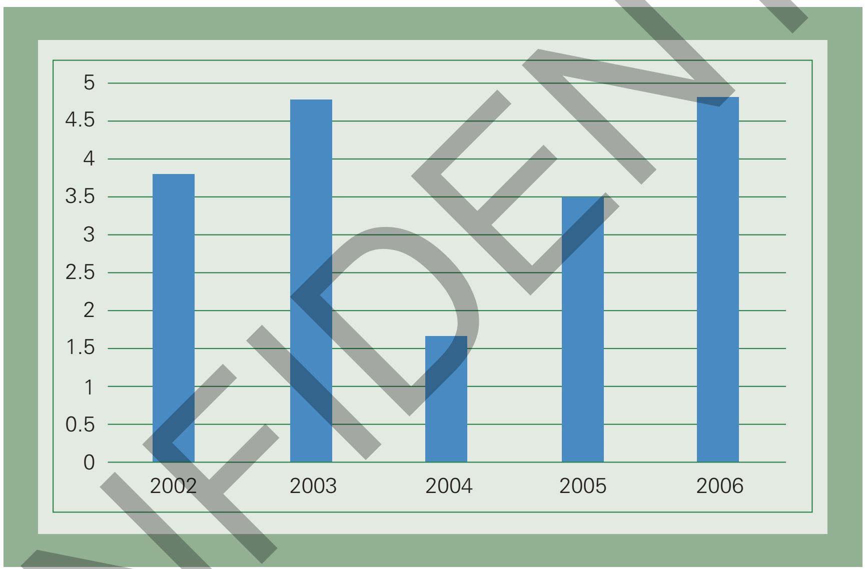
Appendix Figure 3.4 Poultry meat output in china

Source: Guide China Poultry



Appendix Figure 3.5 China's exports of poultry meat

Source: Guide China Poultry



Appendix Figure 3.6 China's imports of poultry meat

Using the rate of reduction in domestic poultry meat production (–11 percent) after the outbreak of SARS and the output meat, poultry and aquatic products in 2014 illustrated above (3.9291 trillion *Yuan*) to infer the possible but the minimum loss in China's animal husbandry industry, the results shows that that the total output loss is estimated to would be 432.196 billion *Yuan* (or USD70.85 billion). Based on the rate of decline in exports during SARS (–10.2 percent), the loss in exports for China's animal husbandry is estimated to be 15.7 billion *Yuan* while imports based on 28.2 percent increase during SARS would increase by 34.75 billion *Yuan* (UDS5.7 billion). Assume that increased imports would have the impact of crowding out domestic production. Thus, the total loss to the animal husbandry industry would equal to loss of output plus the loss of import resulting in a total loss of around 467 billion *Yuan* in China's animal husbandry industry.

Appendix 4
Antibiotics in China: Fact Sheet

1	China was among the 7 pioneer countries (UK, the US, France, the Netherlands, Demark and Sweden) to have developed the penicillin product in 1944.
2	In 2013, China's total antibiotics production was 197,000 tons, accounting for 90% of world's crude drugs output
3	In 2013, China exported 4,300 tons or 28.3% of the total output, accounting for 70% of world's total antibiotics exports
4	Antibiotics are the leader in China's total raw-material drugs exports. In 2015, it exported USD3.7 billion of crude antibiotics, around 10% of total raw-material drug exports. China's surplus was over USD3.2 billion. But crude antibiotics exports only accounted for about 0.1% of China's total exports.
5	Veterinary drugs accounted for about 19 percent of China's total crude antibiotics exports.
6	China is less competitive in export of preparations. In 2015, China exported USD3.2 billion preparations with a deficit of about USD10 billion.
7	About 70 percent of the output is generic drugs and China's antibiotics industry concentrates mostly in the production of low-end crude drugs.
8	Penicillin is the leading exporter of all the product categories. In 2015, total penicillin export was USD892.2 million, accounting for about a quarter of China's crude antibiotic drug exports.
9	Tetracyclines is the leading exporter of veterinary drugs for China. It exported USD280 million of Tetracyclines in 2015.
10	China is the largest consumer of antibiotics in the world, consuming about 160,000 tons, 160 times that of UK（about 1000 tons） in 2013.
11	China per capita use of antibiotics was 138g. the US was 13g
12	China consumed more than half of the global total antibiotics in 2013. About 52 percent was used on livestock and 48 percent by humans. However, "Non-therapeutic use of antibiotics in livestock production makes up at least 60% of the total antimicrobial production in the United States", so this is not a small thing (Todar).
13	Global antibiotics use in food animal production estimated at 63,151 tons in 2010 (up to 50% of all antibiotics sales)
14	In 2012 年，around 4.5 million tons of antibiotics were used in livestock and 34 million tons were used in pigs.
15	The rate of inappropriate use of antibiotics in animal farming could reach 60–90 percent in China
16	Roughly over 60 percent of antibiotics used by food producing animals was directed to promoting faster growth of the animals in China.
17	Share of antibiotics use in Chinese hospitals was 74% in 2006–2007 (CMH). The rate for developed countries was 22%–25%
18	For hospitalized patients, share of antibiotics use was 70% in 2006–2007 (CMH)
19	97% of patients used antibiotics in surgery in 2006–2007 (CMH)
20	According to WHO: 75% of patients with cold used antibiotics; for surgery 95%; for hospitalized patients 80%; use of broad-spectrum antibiotics and two types of antibiotics was 58%.The average rate for international was 30%
21	Share of antibiotics use in Chinese hospitals was 74% in 2006–2007 (CMH). The rate for developed countries was 22%–25%

Continued

22	New Delhi Metallo-beta-lactamase–1 (NDM–1) was also found in Fujian Province in China. New Delhi Metallo-beta-lactamase–1 (NDM–1) was first detected in 2008 and then detected in India, Pakistan, UK, the US, Canada and Japan
23	An official survey for 1995–2007 indicated that infectious diseases made up 49% of total and bacterial infection accounted for 18%–21%. Each year, 80,000 people died of antibiotics misuse in China.
24	The developed provinces such as Guangdong, Jiangsu, Zhejiang and Hebei are seriously polluted by antibiotics residues. The antibiotics emissions concentration in the densely populated east China was six times that in west China. The average concentration of antibiotics in the Chinese rivers was about 303 nanograms per liter. 9 nanograms per liter in Italy, 120 nanograms per liter in the United States, and 20 nanograms per liter in Germany.
25	Of the 36 most common antibiotics products, China used 97,700 tons in 2013 and around 53,800 tons entered into environment, mostly concentrating in the rivers near Beijing, Tianjin and Hebei.
26	It was expected that China's use of antibiotics in food producing animals would account for 30% of the world total by 2030.
27	On August 1, 2012, CMH issued most stringent restrictions on clinical use of antibiotics, generally called "xiankangling" by domestic people.
28	By 2050, 1 million people will die each year from antibiotic resistance in China. O'Neil (2014)
29	In China, the administration of antibiotics is shared by two government agencies. Antibiotics used in humans are administered by the China Food and Drug Administration (CFDA) whereas the antibiotics used in animals are administered by the China Ministry of Agriculture.

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